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Technical Lesson 40

INSTRUMENTS USED IN RADIO SERVICING AND PRINCIPLES OF SET TESTING

This lesson deals with various types of radio servicing equipment not described in other lessons on the subject of radio servicing and in addition you will find in this lesson a detailed explanation of the principles of continuity testing and many hints on service problems. Again our subject will deal principally with the use of meters. It is well known that more accurate testing of receivers is now required than in previous years and this means that a serviceman to be proficient in his work must have a thorough knowledge of testing equipment. He must know how various types of test circuits are arranged and be able to interpret the readings he observes on the test meters. To accomplish all this requires that each one put forth a little concentration on this work and carefully study all diagrams, explanations and points concerning this branch of radio.

MODULATED OSCILLATOR. Unless a serviceman is certain that a satisfactory broadcasting station will be on the air at the time of his service call he will be handicapped unless he carries a modulated oscillator. This simple piece of test equipment, in reality, is a miniature broadcasting station that can be quickly placed in operation to send out a modulated high-frequency wave which is especially suited for making comparative tests in the audio output of a receiver. Its signal is more often desired by servicemen than a regular broadcast signal because its note is steady and uniform in strength and is not affected by outside conditions, or conditions beyond control of the serviceman. A modulated oscillator, therefore, is a very useful instrument to possess since tests can be made on receivers at any place and at any time without depending upon broadcasting stations to supply the signal energy. This instrument can be easily constructed to generate frequencies covering the broadcast band by arranging a feed-back circuit with an inductance of suitable size and shunted by a variable condenser of correct capacitance. The range of broadcast frequencies is between 550 and 1500 kilocycles, or 200 to 546 meters.

By using frequencies in the upper, middle, and lower ends of the broadcast band, when checking up the performance of a receiver, it gives one an assurance that a complete resonance check has been made over the entire tuning range of the radio-frequency circuits. As a general rule the best point of operation is in the neighborhood of 1,400 kc., at one of the higher frequencies, and the desired frequency may be determined by rotating the oscillator's condenser until its wave is picked up on the receiver by setting the receiver's dial to that particular frequency as designated on the dial.

Among the most important uses to which a modulated oscillator can be put is for furnishing a good steady signal by which the tuned stages of single-dial control receiving sets may be placed in resonance with one another. This is

done by making adjustments either to the main tuning condensers or condensers called "trimmer" condensers. Also, a modulated oscillator may be used to advantage in neutralizing the radio-frequency stages of certain radio sets and when matching tubes for best performance.

The circuit diagrams of two modulated oscillators that work on similar principles are shown schematically in Figures 1 and 2. The oscillator in Figure 1 can be made into a compact portable instrument because all that is required to set the oscillator system into oscillation is to plug in on either an a-c or d-c power line of 110 volts. It is possible to operate such a circuit on a power line because a standard 25 watt lamp is inserted in series with the filament circuit. The oscillator in Figure 2 receives its operating voltages entirely from batteries as the diagram indicates.

It can be readily seen in Figure 1 that a 50 turn coil wound with No.20 double cotton-covered wire on a form $2\frac{1}{2}$ inches in diameter comprises the single inductance used in this circuit and this coil is shunted by a .0005 mfd. variable condenser to complete the tuned circuit elements. A tap is taken off at the 25th turn of this winding and the wire that connects this tap to the filament provides the grid and plate return circuits of the tube. The upper half of the coil forms the grid circuit inductance and the lower half the plate circuit inductance and the coupling between the two coil sections provides the requisite feed-back voltage. This voltage is power transferred from the plate circuit to the grid circuit and this voltage causes the system to generate continuous oscillations. A second coil, called a pick-up coil, consisting of 4 turns of rubber-covered wire is wound over the large coil, and when it is properly connected to the input terminal post of a receiver the pick-up circuit carries the signal energy from the oscillator to the receiver.

The grid condenser and leak resistance combination modulates the output of the oscillator and if a change of tone is desired it can be obtained by changing the value of the leak resistance. We recommend, however, that for a circuit of this type the pitch of the audio-frequency modulating note will be satisfactory if you use a grid leak rated at 4 megohms. The oscillator in Figure 1 will have a 60 cycle modulating note if it is operated on a 60 cycle, 110 volt line, but this audio note obtained due to the alternating current will not seriously impair the sharpness of the signal wave sent out by this circuit.

If you intend to build up a test instrument of this kind it would be best to assemble the parts either in "breadboard" fashion or on an insulated panel and then mount the assembled unit in a small metal box or cabinet. to completely

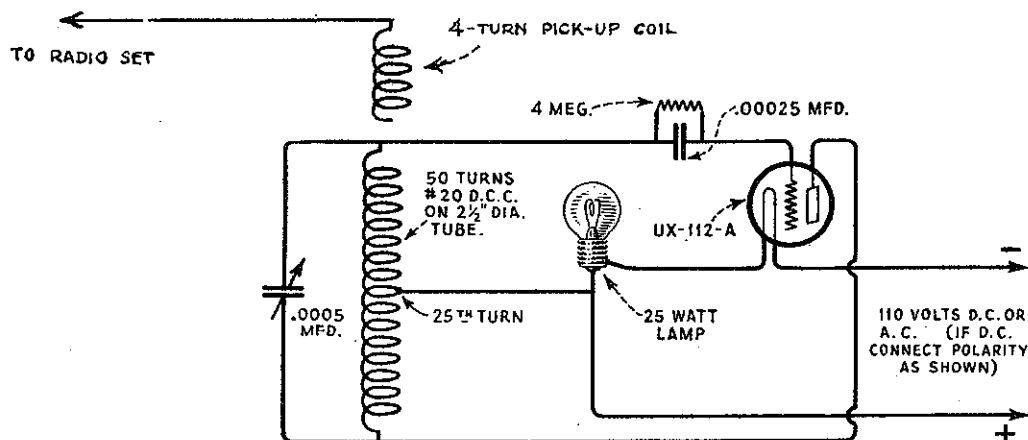


Figure 1

shield the oscillator; a tin box or a wooden box which is tin or copper lined will answer the purpose. If you build a socket-powered oscillator you should guard against a possible short-circuit between the 110 volt line supplying the oscillator and the ground of the receiving set being serviced by using rubber-covered wire for the pick-up coil and other main wiring connections.

When employing a modulated oscillator in conjunction with a receiver the oscillator should be placed about six feet away from the receiver and the pick-up lead should be connected to the antenna post of the receiver and then, providing the receiver is functioning as it should, you will hear a musical note in the loudspeaker, or if an output meter is connected to the loudspeaker terminals the needle of the meter will deflect and indicate the presence of the signal current in the circuit.

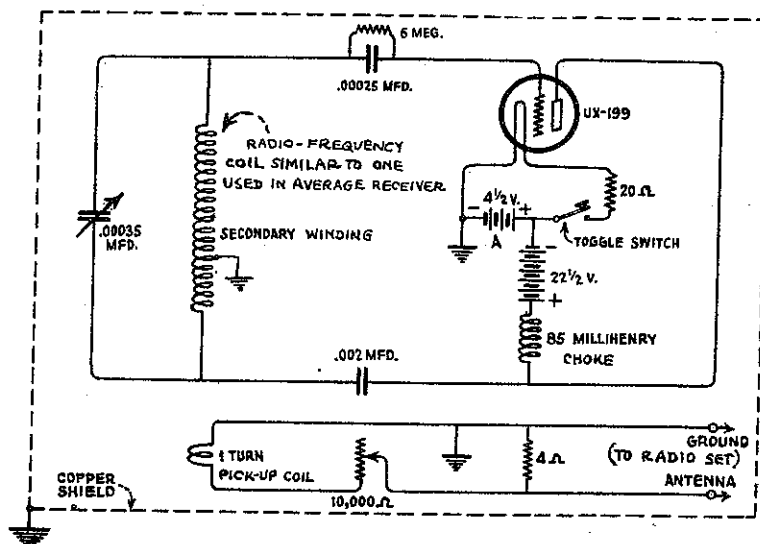


Figure .2

When synchronizing radio-frequency stages, or compensating, or phasing these stages which mean the same thing, you should have a good connection of the pick-up lead from the modulated oscillator to the antenna terminal post of the receiver and the oscillator should be so adjusted that its signal energy will be very weak and, furthermore, you should use the regular tubes on which the receiver ordinarily operates.

It is a matter of convenience to have some means of controlling the strength of the oscillator's signal and one simple way to accomplish this is to insert a variable condenser in series with the pick-up lead. By varying the capacitance of this condenser the path through which the signal current must flow can be made to offer more or less opposition due to the reactance set up by the condenser which tends to oppose the flow. Control of the oscillator output in the circuit in Figure 2 is affected by adjusting the variable resistance connected in the pick-up circuit. If no provision were made to regulate the signal strength of an oscillator you could help matters by removing the pick-up lead from the receiver terminal post, wrap a piece of paper or a rubber band around the post and then twist the pick-up wire around this insulation and, thus, with this arrangement there would be no direct metallic connection between the pick-up wire and the post. It is quite important that the signal strength be under control so that it can be intensified according to requirements.

To keep losses of energy from the oscillating circuit at a minimum the connection leads between the tube socket terminals and the r-f coil and its variable condenser and grid-leak combination should be as short as is practicable to make them and the pick-up wire should be brought through an insulating bushing in the side of the cabinet. Also remember that the radio-frequency coil should never be mounted too close to the shield because the metal has a tendency to absorb signal strength and if this were allowed to occur it would decrease the output of the oscillating circuit.

The operation of a modulated oscillator will in no way interfere with regular broadcast reception on neighboring sets if it is enclosed in a shield and if the pick-up wire used is a shielded wire—a length of copper-braided rubber-covered wire. The pick-up in Figure 2 should not radiate.

Let us explain that if a short-circuiting switch is shunted across the grid leak-condenser unit in Figures 1 and 2 and this switch is closed the r-f oscillations generated by the oscillator will not be modulated and, therefore, the instrument would be called an r-f oscillator since it would send out continuous oscillations of constant amplitude similar to the carrier frequency of a broadcasting station.

A service test oscillator which covers a band of frequencies somewhere in the range of 175 kc., or in the intermediate frequency range, is required for testing the intermediate amplifiers of superheterodyne receivers but inasmuch as these circuits are especially designed for certain intermediate frequencies used in different makes of receivers we will not go into a further discussion of this type of oscillator otherwise than saying that the same principle is employed in both types of oscillators to generate the oscillations, that is, they both employ a feed-back circuit and inductance and capacitance units of suitable values.

HOW TO USE AN OUTPUT METER FOR MAKING AUDIO OUTPUT COMPARISONS. When making adjustments or tests that require an appreciation of quantitative values to determine the best operating condition of a receiver's circuits you can get more accurate results by employing a sensitive meter in the output of the receiver to show the different levels of volume of the signal coming through than if you depended upon your hearing and judged these different levels by sounds produced in either headphones or loudspeaker. Everyone is quite aware of the fact that the ear is not as reliable as the eye as an indicator for comparing quantitative values, such as the strength of any output audio comparisons, but it should also be understood that there are still some persons in

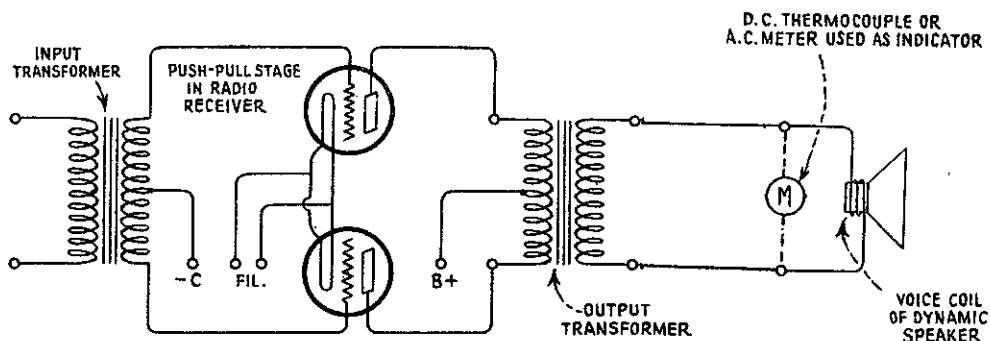


Figure 3

radio who prefer to use the audible method and listen to the signal, largely because they have become accustomed to the latter practice. To get maximum results from a receiver all of the tuned r-f stages should be in close synchronism or resonance over the entire tuning range. If one or more of the tuned stages are completely out of synchronism the signal will not pass through the receiver and for slight variations in resonant conditions due either to misalignment of tuning condensers, or incorrect adjustment of trimmer condensers, then these r-f circuits would allow signals to pass, but the signals would be more or less weak and the tuning would be considerably broadened.

When making adjustments to trimmer condensers, or aligning tuning condensers, or when neutralizing r-f circuits a modulated oscillator could be used to supply a steady signal and the output meter would measure the alternating or pulsating component of the signal current.

When the tuned circuits of a receiver are being synchronized the strength of the output signal increases as resonance is approached and the test meter will indicate this increase and as each of the tuned circuits are brought more into resonance the reading will continue to increase until finally a maximum reading will be observed when all stages are in resonance. For making audio comparison test on receivers that do not have an output transformer, such as you find in the modern sets, a suitable output meter for this purpose could be easily made up with an a-c milliammeter attached to the "low side" of a toy transformer having a ratio of 20 to 1 or a voltage reduction transformation of 110 to 5 and the "high side" attached to the receiver's output. An a-c milliammeter with a 0-100 m.a. scale could be used with such a transformer.

An output meter may be used as an indicator when neutralizing a receiver and in this case the best adjustment for a given neutralizing condenser is taken to be the point where the meter gives a minimum deflection. The lowering of the reading is accounted for in this case because a "dummy" tube is used when neutralizing and the signal should not pass through a properly adjusted r-f stage holding a "dummy" tube since the filament of such a tube is made inoperative and, therefore, there can be no electron emission, but the grid and plate are left intact. Of course, when the "dummy" tube is removed and replaced by a normal tube the signals will come through and you should then get a maximum indication on the output meter providing the tuned stages are in synchronism or resonance.

A single dial receiver of modern type is provided with some mechanical means of adjusting its r-f stages thus making it possible for the serviceman to compensate for any variation in condenser units that would cause a difference in synchronism between the several tuned r-f stages. In general, these mechanical adjustments are made by means of adjustment nuts or screws on small variable capacitors, called trimmer condensers, which are incorporated in the design of each tuning section of a gang-condenser, or if separate units are used you might find vernier condensers which are used for practically the same purpose. Then again in certain receivers the alignment of tuning condensers is made by means of set-screw adjustments which allow the rotor plate sections to be slipped on their common shaft, or in some types a belt drive or lever drive, if used, may need adjusting, and there are cases that you will perhaps encounter where the capacitance of an r-f stage is altered by slightly bending the condenser plate segments.

An inspection of the construction of a receiver will in most cases show what mechanical means are provided for placing the tuned r-f stages in electrical synchronism with one another and, also, the procedure itself may vary as to whether the r-f stage adjoining the detector should be aligned first or last to perform the work in the shortest possible time.

We can see that although the mechanics of aligning or synchronizing an r-f amplifier may differ with different sets yet the principles always remain the same. A radio serviceman can easily cope with this problem because he has two places where he can connect a sensitive meter to give the proper indication; he can choose between placing the meter in the plate circuit of the detector, or in the output of the set, that is, in the output of the last audio stage.

If the meter is to be inserted in the detector plate circuit a d-c milliammeter would be required and its range should provide a full-scale reading just slightly higher than the normal plate current of the particular tube with which it would be used. It will be found that in the case of detectors which in general employ a grid-leak condenser combination that a greater change in plate current can be expected when the signal is coming through than from a receiver using a power detector. And, furthermore, in the case of the grid-leak grid-condenser detector the plate current will drop below normal and, hence, a minimum reading is taken to indicate when the resonant point has been reached between the different radio-frequency stages of the set. On the other hand, in the case of a power detector the plate current will increase above normal and, therefore, maximum current in this case is taken to indicate resonant conditions.

If the indicator is to be used in the output of a radio set the following points should be considered, namely, whether the last audio stage consists of a single tube or two tubes in push-pull and whether or not an output transformer is supplied. In either case a thermo-couple galvanometer, if used, should be connected to the plate circuit through a step-down transformer such as is customarily used to connect the output with the voice coil of a dynamic speaker. Of course, if a transformer is already provided then you would need only connect the thermo-couple galvanometer to the two transformer terminals to which the voice coil is normally connected. If you come across a receiver which has its output circuit connected to a dynamic speaker but there is no convenient means provided to disconnect the voice coil leads you could in this case connect the meter directly across the voice coil thus permitting the latter to remain in the circuit. Our diagram in Figure 3 shows the connections.

Be careful when making adjustments to the r-f stages of a set to see that the input signal does not vary in strength and that the r-f stages are kept continuously in tune with this signal. The most satisfactory results can be explained if you use a test oscillator to supply the signal as we have already explained and since the operation of an oscillator is directly under your control it is best to adjust the strength of the input signal to give readings on the meter about two-thirds across its scale where the changes in current are more easily read.

Several types of meters are generally used as output indicators for making audio comparison tests among which are the following: d-c milliammeters having scales of 0-1 m.a., 0-3 m.a., 0-5 m.a., and a-c voltmeters having scales of

0-3 and 0-5 volts. A thermo-couple galvanometer marked in equal divisions from 0-100 and which takes approximately 112 m.a. to give a full scale reading and is rated at 4.5 ohms makes a very suitable meter to be used with an output transformer. The higher reading meters are most generally preferred because they do not overload so readily and are better suited for all around testing. Remember, a d-c meter used as an indicator is inserted in the plate circuit. In making output audio comparative tests a serviceman is not interested in the exact values of current or voltage obtained but only in the degree of difference in the intensity of the signal output of the receiver.

AN OSCILLATOR MAY BE USED AS A WAVEMETER. To place either the oscillator in Figure 1 or Figure 2 in condition for calibrating the dial readings on the tuning condenser against wavelength, or frequency values the oscillator may be used as a wavemeter. To make this calibration proceed as follows: Remove the grid leak and grid condenser and connect the grid directly to the tuned circuit, or connect a jumper wire across the grid leak and grid condenser, or shunt a switch across this combination. Without the grid leak-condenser combination in the grid circuit you have a straight r-f oscillator without modulation.

Now place a receiver in operation and tune in the signals of a broadcast station whose frequency is known or can be easily ascertained and couple the oscillator to the receiver so that the oscillator's frequency will be impressed on the incoming broadcast frequency. By tuning the oscillator carefully you can make it generate a frequency either a little above or below the broadcast frequency to set up a heterodyne beat note which will be heard as a shrill whistle in the loudspeaker. The frequency of the beat note is the numerical difference between the oscillator frequency and the broadcast signal frequency. The beat frequency is made to come within the audio range by varying the oscillator's tuning condenser, as just suggested, but always keeping the dial of the receiver in a fixed position according to the broadcast signal used for this test.

If, at the position where you hear the beat note, you rotate the oscillator condenser dial slowly back and forth you will locate a point on the dial where no beat note or whistle is heard; this point is known as the "dead spot". If you move the dial just a little either one way or the other from this "dead spot" the note will reappear. The dead spot indicates that the r-f circuits of both the receiver and the oscillator are in exact resonance and, therefore, are tuned to the same frequency. You have now located one frequency point on the oscillator dial and you could mark down this frequency which corresponds to the broadcast station's frequency whose program or signals you are tuned-in on. Other stations of known frequency covering the broadcast band could be tuned-in and checked in the same manner and the oscillator dial could be marked with the frequencies of those stations and the dial could be thus calibrated from one end to the other. By locating about 8 or 10 points evenly across the dial these calibrations could also be plotted on cross section paper on which you could read other intermediate frequencies not actually calibrated by a signal of known frequency. Your curve would be constructed in the usual way by drawing through intersecting points after plotting frequencies on one axis and dial divisions on the other.

After an oscillator is once calibrated it will come in handy whenever it is desired to check the frequency of any particular setting of the tuning dial of a receiver. To check up the frequency marking on a receiver's dial you would have the oscillator's signal modulated, and tune the receiver for this signal the same as you would do to bring in a regular broadcast signal and when the signal is heard in the loudspeaker with greatest intensity you know that all radio-frequency circuits are in resonance. Or, if an output meter were used you would look for a maximum indication to denote resonance.

There is still another way to check up the frequency markings on a receiver's dial by connecting a milliammeter in series with the oscillator grid in place of the grid leak-condenser combination and use the oscillator circuit as a grid dip meter. When the condition of resonance is approached between the receiver and oscillator a certain amount of r-f energy will be extracted from the oscillator tuned circuit by the receiver's tuned circuits and you will be aware of this fact because the pointer of the milliammeter will swing backward on the scale and then, at the exact point of resonance the pointer will have its maximum backward dip. Thus, either a visual or audible indication will serve as a check on resonant conditions between an oscillator and a receiver.

GRID DIP METER. The diagram in Figure 4 shows how an r-f oscillator may be easily converted into a grid dip meter by merely inserting a low range milliammeter in series with the grid circuit. This meter will show whenever energy is induced into some other oscillatory circuit from the oscillator's tuned circuit. If r-f energy is extracted from the oscillatory circuit of an oscillator it reduces the amount of feed-back current that normally flows to the grid and any slight change in load drain on this account can be observed through the movement of the meter's pointer. Thus, the use of a milliammeter in the grid circuit of an oscillator provides a good means for checking up resonant conditions between two r-f circuits.

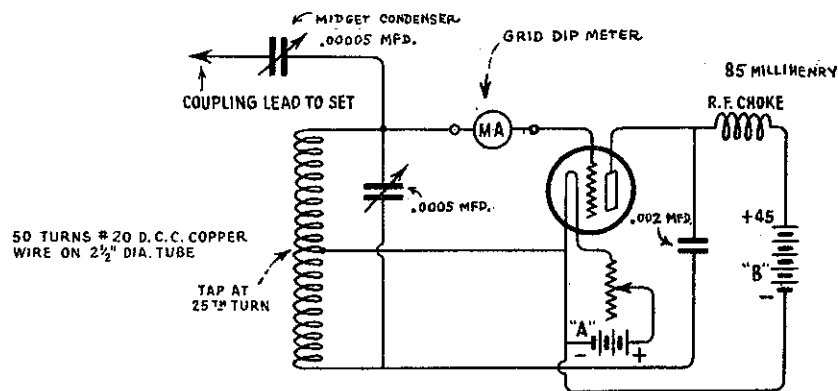


Figure 4

If any r-f circuit to be tested is suitably coupled to the oscillator and both circuits are tuned to the same frequency, that is, they are in resonance, the r-f circuit under test will absorb the maximum amount of energy and, obviously, the oscillator at that time will lose the most energy, and this condition is immediately evident by watching the milliammeter. Its pointer will dip backward toward zero at the resonant point. Then if you alter the setting of the respective dials of either r-f circuit by rotating the dials one way or the other it will throw the circuits out of resonance, that is, it will detune

them and the meter will again indicate maximum current in the grid circuit. Hence, a grid dip meter can be used to compare tuned r-f circuits of receivers and allows us an easy means for testing coils, condensers, and so on.

A d-c milliammeter with a range of either 0-1, or 0-1.5 m.a. makes a satisfactory instrument to be used in a grid dip meter circuit. The same meter could be converted into a voltmeter or ohmmeter by using a suitable resistance in series as we have already explained.

A few points on the practical operation of a grid dip meter follow: It is best to have loose coupling between the oscillator and receiver, or the tuned circuit being checked. If the tuned circuits of a receiver are being tested it is sufficient, if the oscillator is not shielded, to locate it within a foot or two of the receiver, or if the pick-up wire is used it would be attached to the terminal post of the radio set, or the wire may be placed close to the antenna lead without being electrically connected to it. When other tuned circuits are checked which are not shielded the inductance of the circuit under test should be placed in the field of the oscillator for the proper transfer of r-f energy. If the circuits are properly coupled the meter pointer will gradually drop back until the point of resonance is reached and the pointer will gradually return to normal position after the point of resonance has been passed. Insufficient coupling would be indicated by the tuned circuit having little or no effect upon the meter regardless of its frequency setting. If the circuits were coupled too close it would be indicated by the pointer flying forward on the scale to maximum position when the resonance point was passed. It will not prove an easy matter to locate the exact point of resonance between two r-f circuits when the coupling is too close.

FLEMING VALVE INDICATOR. The resonance indicator shown in Figure 5 is a very simple device consisting of a vacuum tube, a d-c milliammeter, a rheostat and battery. It is known as a Fleming valve indicator after the original inventor of the two-electrode vacuum tube; a tube which was built with only a plate and a filament. As the diagram shows the grid and plate are tied together to make these elements act similar to a single plate so that any positive potential on the plate will attract electrons from the hot filament and set up a flow of current through the milliammeter. Of course, no current will flow when a negative potential is applied to the plate. Thus, the milliammeter measures the rectified current. The rheostat can be adjusted to con-

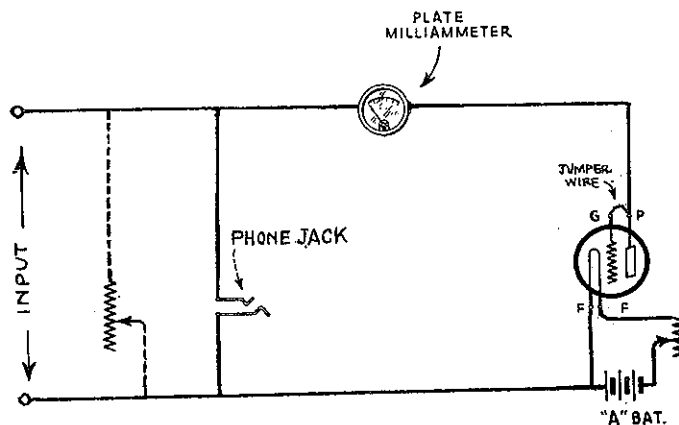
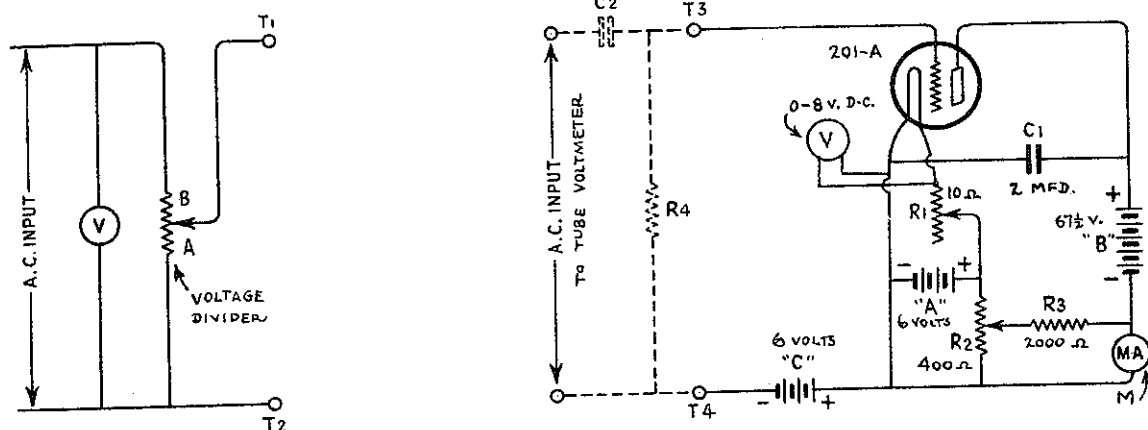


Figure 5

A very compact and extremely responsive circuit may be easily constructed by using a d-c milliammeter with a range of 0 to 1.5 m.a., a small tube such as a UX-199, a 25-50 ohm rheostat and 3 dry cells; don't put more than 3.3 volts on the filament of this type of tube. In practical operation the two terminals, marked "INPUT", are connected across the voice coil terminals of a dynamic type speaker exactly the same as for any output meter as already explained. However, if the circuit is to be used to test a receiver's output that does not employ a dynamic speaker a variable resistor should be shunted across the input, as shown in the diagram, to protect the milliammeter against burnout from excessive current and, also, a pair of headphones could be connected across the input circuit which would permit you to listen to the signal.

The principle on which a vacuum tube voltmeter operates is that of a detector. If an e.m.f. or voltage is impressed on the grid it causes a certain change in plate current to take place and for a given set of working conditions the same value of impressed voltage on the grid will produce the same change in plate current. By looking at the diagram of a typical vacuum tube voltmeter in Figure 6 it is evident that the input voltage is applied between the grid and filament of the tube.



In setting up a vacuum tube voltmeter you should use a well-aged tube and a d-c milliammeter with a range of approximately 0 to 1 m.a. and at the start make adjustments required to place the milliammeter pointer on "0". It is essential that the circuit to which the vacuum tube voltmeter is connected be so arranged that the direct current biasing voltage is applied to the grid. The range of usefulness of the tube voltmeter may be extended somewhat by varying the plate voltage and grid bias to suitable proportions and, also, by employing tubes of different types. Any of several types of tubes are suitable for this purpose, such as 112-A, 201-A, or 199 tubes.

If you have previously applied known values of a-c voltages to the input of the tube voltmeter and noticed the amount of deflection on the milliammeter for different values when operating the circuit under certain fixed conditions the meter reading could be calibrated in terms of a-c volts; this would also apply to different d-c voltages that might be applied to the input of the tube voltmeter. Thus, with a calibrated scale you could measure gain, hum, output, and so on. To measure extremely low voltages, such as hum, it might be necessary to connect in a stage of audio amplification ahead of the voltmeter tube input.

Let us now discuss the general features of the tube voltmeter circuit shown in Figure 6. The purpose of potentiometer R2 and resistor R3 is to supply a reverse current through the milliammeter to that of the normal or steady plate current. This permits you to adjust the circuit to give a zero reading on the meter before you begin a series of measurements or comparisons. There are times when you might wish to adjust the meter pointer for false zero at a division on the scale, for example at .1 m.a. or higher to work the meter where it will give the best indication. Another way to supply a current that will balance out the steady plate current that flows when no signal voltage is applied to the tube's grid is to set up a battery and rheostat and protective bulb across the meter terminals after the manner described in your text relating to a tube tester.

If the vacuum tube voltmeter is connected to a circuit that will not pass the biasing voltage, as previously referred to, a blocking condenser C2 and grid leak R4 should be used in the positions shown by the dashed lines. The values of these units will depend upon circuit conditions, but in general a condenser of large capacitance should be used to offer as little reactance to the a-c input as possible and the resistance of the leak should be of a comparatively lower order. A condenser of about 2 mfd. and a resistor of about 250,000 ohms will usually answer the purpose.

A method for calibrating a vacuum tube voltmeter is shown in the sketch at the left of the tube voltmeter diagram in Figure 6. It shows that a known voltage is impressed on a voltage divider and a certain part of this voltage is in turn applied between grid and filament of the tube, the exact amount being governed by the position of the movable arm on the potentiometer. The resistances of sections A and B on the divider are also known quantities, and the terminals marked T1 and T2 are connected by short leads to terminals T3 and T4 when calibrating the instrument. To calibrate the scale on the meter M in volts, the volt readings would be the numerical result obtained after dividing $\frac{A}{A+B}$ into the measured voltage V, or input voltage applied to the divider.

With an ordinary milliammeter of 0 to 1.5 m.a. range used at M the voltage range on a calibrated scale would be of a fairly low order, or in other words input signal voltages from about 0.5 to 3.0 volts could be satisfactorily measured. For the greatest accuracy you should adjust such a circuit, that is, adjust the relation of grid bias volts to plate volts to get the greatest swing of the meter's pointer for a given input signal voltage. Where very close measurements are required a 0 to 200 microammeter is generally used and the entire unit, except the input terminals and control knobs and meter, is mounted in a shielded box or cabinet to prevent stray energy from affecting the operation of the circuit.

HOW TO MATCH RADIO-FREQUENCY COILS. A thermo-couple galvanometer with an evenly divided scale of 0 to 100 is a suitable instrument for use when making resonance tests between r-f circuits. Since an oscillatory circuit consists essentially of inductance and capacitance we can use a standard of one to help us select a required value of the other. In other words, you may wish to measure the frequency range of a certain radio-frequency coil and this could be done by conducting a resonance test by using a condenser of known capacitance which in most cases would be a variable condenser having a capacitance range equal to the tuning condenser generally used with the coil in question.

In making such a test on a certain r-f coil, the coil should be connected in series with a condenser of known value and the thermo-couple galvanometer. Any test oscillator previously described would be operated as a straight r-f oscillator with its output carried to the coil either by means of the pick-up lead which could be located close to the coil, or the lead could be run through the center of the coil and around it in the form of an open-end loop.

Then the condenser of known capacitance is set for maximum value and the oscillator's condenser is rotated until the galvanometer in the unknown coil circuit indicates a maximum deflection. You can read the frequency or wavelength on the oscillator's condenser dial, providing it has been previously calibrated, and this setting will be the maximum wavelength, or lowest frequency for the unknown coil when used with the condenser of given value. The minimum wavelength, or the highest frequency is obtained in the same manner by setting the known condenser to its minimum value, that is, with its rotor and stator plates completely out of mesh and also lowering the oscillator condenser capacitance until the galvanometer again reads maximum, thus indicating that the largest amount of r-f energy is being induced in the r-f circuit under test. By reading the markings on the oscillator dial you can determine the low wavelength or maximum frequency of the circuit under test. Thus, we get upper and lower frequency or wavelength limits of the coil under test when used with the known condenser. By employing the same principle a condenser of a certain size can be selected by using a standard of inductance, or the inductance that is generally employed with a condenser of the particular type to be selected.

If you wish to match a radio-frequency coil, or if you wish to match condensers to some other coils having a similar inductance value you could make a resonance test between the oscillator and one coil and condenser combination and by substitution you could replace either the coil or condenser or both until similar resonant conditions were obtained all around. It is to be understood that for most ordinary service work where it is desired to test r-f coils for shorts, or to match coils and condensers for replacement purposes you could use a grid dip meter in the test oscillator to indicate resonant conditions instead of the thermo-couple galvanometer although the latter is preferable.

Procedure for Balancing Radio-Frequency Circuits. The receiver is placed in full operation with normal tubes in place and tuned to a test oscillator signal of about 1400 kc. A special tube must be used that is entirely normal except its filament circuit must remain open to prevent electron emission so that a signal will not pass through the tube. When this "dummy" tube is selected about one-half of one of its filament prongs should be sawed off. Remove the r-f tube in the last r-f stage and insert the dummy tube in place only far enough to allow the three long prongs to make contact and adjust the neutralizing or balancing condenser for this stage until the signal disappears. There will be no signal or perhaps a minimum signal when the stage is properly neutralized. Now remove the dummy tube and reinsert the normal tube and signals should again come in strong. Repeat this operation at each r-f stage.

MEANING OF CONTINUITY TESTING. While some of the explanations about radio servicing given in our lessons may be familiar to a few who have had a little experience in this branch of radio there is no doubt but that certain parts will bear repetition because they usually represent the very items that a more experienced serviceman would consider when shooting trouble on a radio receiving set.

A continuity test circuit consists of a telephone headset and battery, or a voltmeter and battery, or an ohmmeter and battery and suitable test leads. A continuity test set made with a voltmeter, a "C" battery, and the necessary wires is pictured in Figure 7. Note that one terminal of the battery and one terminal of the voltmeter are connected together with a short lead and the two remaining terminals are connected by a pair of long rubber covered leads with test prods or points. These points consist of insulated handles through which are run the wiring and the metal points or prods themselves. In the construction of such a circuit the maximum voltmeter range should not be much greater than the voltage of the battery so that the pointer of the meter will give a comparatively large deflection when testing through a circuit with a fairly low resistance. A convenient way to express the indication we get on a meter is to say we get a deflection of $1/4$, $1/2$, $3/4$, and so on depending how far the needle moves across the scale. In Figure 7 the drawing shows a continuity tester being used to check a winding of a transformer. A schematic of this circuit using symbols for the parts is given in Figure 8.

This part of your work is divided into four sections to give you the practical methods employed to check the condition of parts and wiring that constitute a radio set and these explanations should prove a guide for anyone performing this work for the first time. Of course, after each one of us has had some experience in analyzing set troubles and making tests we work according to a system which best suits our needs. The four sections are: (1) Testing different forms of windings or coils, power transformers, audio-frequency transformers, and radio-frequency transformers, (2) Testing resistors, (3) Testing variable tuning condensers and large and small fixed condensers and condenser blocks, and (4) Testing or checking through circuits in which coils, condensers, and resistors are wired together as you might find them to be in a receiving set or power system. For the latter purpose we have selected a typical filter circuit such as is used in the majority of receivers today and, also, a simple circuit consisting of a coil, two resistors, and a condenser with ground connections made at two points in this circuit.

- (1) Our first explanation will deal with testing coils and windings.
The continuity tests as pictured in Figures 7 and 9 are conducted as follows
Suppose you touch the test points to the primary "P" terminals as shown and the voltmeter does not read it indicates an open or break in the winding. If the winding were perfect the voltmeter would give an indication and the distance the needle moved across the scale would be governed by the resistance of the coil. If an ohmmeter were used instead of a voltmeter you could get a direct reading of the resistance in ohms. Now, if the test points are touched to the two secondary "S" terminals the meter will not read if this winding is open but it will read if the winding makes a complete circuit through which the direct current can flow. By touching one test point to a "P" terminal and the other test point to an "S" terminal we should get no reading since these coils are not connected in any way, but if we did get an indication on the

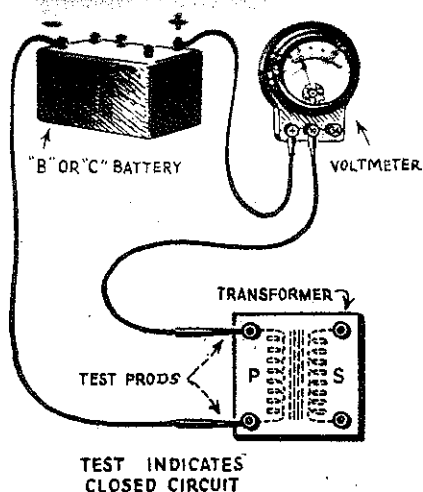


Fig. 7

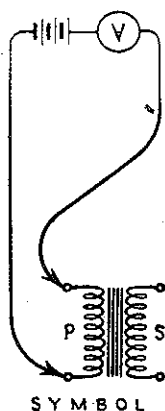


Fig. 8

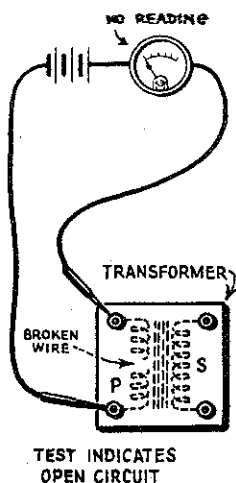


Fig. 9

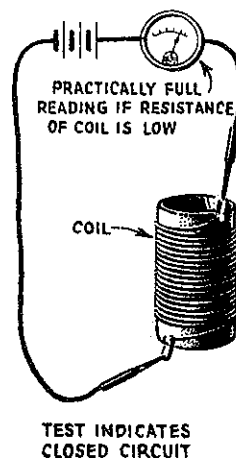


Fig. 10

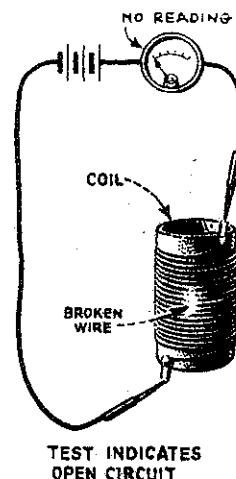


Fig. 11

meter we would know that the turns of one coil touched the turns of the other and this would constitute a short-circuit. This is practically all there is to testing any form of winding for its continuity, that is, to determine whether the winding is open or closed and whether its turns touch the turns of another winding, or a metallic part for instance, from which the coil you are testing is supposed to be insulated. We will also mention that if one test point is touched to either a "P" or "S" terminal and the other test point to the iron core there should be no indication since the turns comprising the windings are carefully insulated from the iron; a reading would mean that the turns at some location are touching the iron and if this occurred the winding would be shorted to the core. In Figures 10 and 11 we show a radio-frequency coil being tested in exactly the same manner as the transformer windings in Figures 7, 8, and 9. The indications to be expected for "open" and "closed" circuit conditions in continuity testing are plainly marked on each drawing.

- (2) Our second explanation will deal with testing resistances or resistors. The continuity tests as pictured in Figures 12, 13 and 14 are as follows: The second part of our instructions on continuity testing deal with checking resistors for resistance as well as for continuity. The same method is used as for windings of any description as you see by examining the drawings in Figures 12, 13 and 14. Suppose you touch the test points to the terminals of the resistor in Figure 12 as shown, the voltmeter or ohmmeter, which ever is used, will read if the winding is continuous or unbroken.

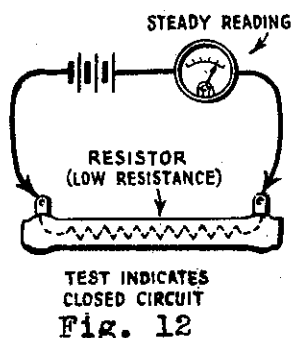


Fig. 12

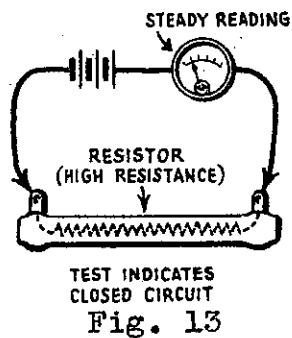


Fig. 13

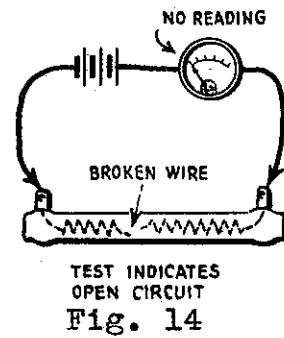


Fig. 14

A high voltmeter reading will be observed when measuring any type resistor of low resistance, and a comparatively lower voltmeter

reading will be had for a higher resistance and, of course, if an ohmmeter is used it will give the ohmage direct on its scale providing the resistance value comes within the limits of the ohmmeter's scale. By making a comparison between Figure 13, which shows a high resistance being checked, and Figure 12 showing a low resistance under measurement you can see the comparative indications on the voltmeter for either case. Suppose you now test a resistor which has either a burned out or broken wire then the indication will be as shown in Figure 14; the meter will give no reading since the circuit is open and will not pass current. If any of the turns of a resistor were shorted you could detect this by using an ohmmeter and knowing the resistor's rated value in ohms. One way to test a grid leak for continuity is to use a test circuit consisting of headphones and a "B" battery of about 22.5 volts in series with the leak and each time the circuit is "made" by touching the test points you should hear a click providing the leak resistance is not open at any location and forms a complete circuit. We mentioned previously that headphones and battery may be used for ordinary continuity testing and this method is called the "click" test.

- (3) Our third explanation about practical testing deals with condensers. The tests and the correct and incorrect indications as pictured below in Figures 15, 16, 17, and 18 are practically self-explanatory. In general, there are two types of condensers, the variable air type or tuning condenser and the fixed type; the latter being classified usually into two groups, namely, small capacity and large capacity condensers. The various tests on condensers are made as follows:

When testing fixed condensers a serviceman wants to make sure of two things, one is that the condenser is not short-circuited or open-circuited and the other is that it has the ability to take on a charge and hold it a certain time and then discharge. A test circuit consisting of headphones and battery as shown in Figure 15 could be used in testing small capacity condensers which range from about .01 mfd. and less. With lower capacities the displacement current is so small that an ordinary meter is not affected by it, whereas, headphones are very sensitive to minute currents and a noticeable click is heard upon making contact with the terminals of a condenser which is not open-circuited. If the condenser were short-circuited you would get a very loud click, in fact just as loud as though you were to touch the test points together without the condenser in the

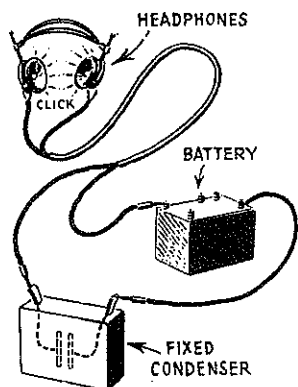


Fig. 15

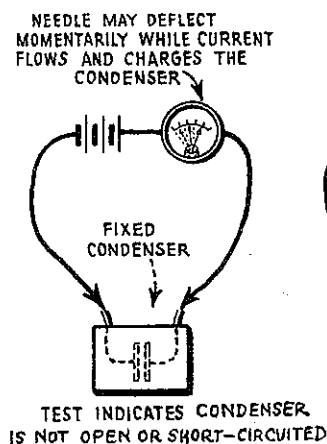


Fig. 16

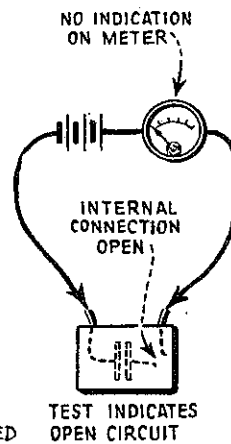


Fig. 17

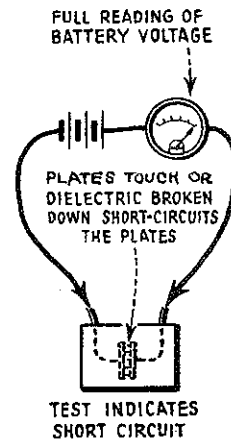


Fig. 18

circuit. After the short-circuit test is completed you should then make an open-circuit test that you can depend on by connecting the condenser across a voltage supply, say a 45 volt "B" battery, for a couple of seconds. Then disconnect the battery and touch the phone tips across the condenser terminals being sure, of course, to hold only the insulated part of the phone cords so that your fingers will not touch the metal part of the tips. If you do not take this precaution you will get an erroneous indication. A click will be heard when you first make contact if the condenser is in good condition. This test proves that the condenser took on a charge, held it for a few moments and then sent its discharge current through the phone windings. The loudness of the click will depend upon the intensity of the discharge current, and it will be louder for condensers of higher capacities and comparatively weaker for lower capacities.

A continuity test circuit consisting of a battery of about 45 volts and a voltmeter, as shown in Figure 16, may be used to good advantage when testing condensers of medium capacity, or those in the neighborhood of .01 mfd. capacity. When a condenser under test is connected to the test circuit as shown in Figure 16 and the meter does not give a steady reading you can be assured that no short exists. Bear in mind, however, that you might get a slight momentary deflection of the meter pointer, as indicated in Figure 16, which is perfectly O.K. since this movement is caused by the flow of displacement current that charges up the condenser. After the condenser is charged the pointer should immediately drop back to zero.

It has been repeated many times that when you connect a source of e.m.f. to a condenser's terminals you simply charge up the condenser which means that a flow of current is set up momentarily. Hence, if a condenser is fully charged and you again connect the charging source to the same condenser you should not notice the usual small spark that occurs between the test point and the condenser terminal at the moment of contact at the original charging of the condenser. If a spark is observed each time you connect the voltage supply to the condenser terminals without discharging the condenser in the meantime it indicates that the condenser is "shot", that is, it will not take on a full charge and hold it. It is to be understood that no spark will be seen either at the time of charge or discharge when testing condensers of small capacities.

Testing Condensers used in High Voltage Circuits. It is often necessary to apply a fairly high voltage when testing by-pass and filter condensers of the type found in filter systems and socket power units and so on. The first step when testing such condensers is to make certain that the condenser is not short-circuited or open-circuited and as we already suggested this rule should apply to all condenser test procedure. Figures 19 and 20 illustrate

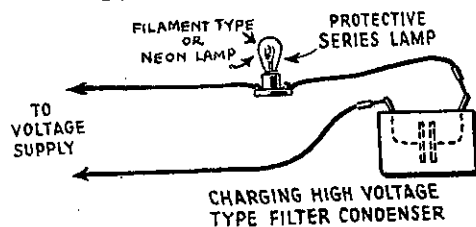


Figure 19

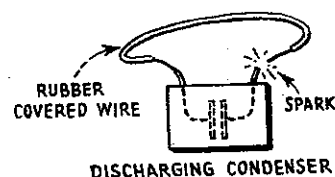


Figure 20

how a condenser under test can be first charged from a high voltage source through a protective lamp and later discharged by means of a short length of wire. A rubber-covered wire should be used for this purpose and only the extreme ends should be bared where contact is to be made. Some persons use a wooden handled screw driver using the metal shank to form a short between the condenser's terminals. Always be careful when discharging a high voltage condenser by this method and hold only the insulated part of the wire, or the wooden handle of the screw driver if the latter is used, or in other words never permit any part of your body to touch the metal parts and thus avoid a possible shock.

Condensers with capacities ranging from about .01 mfd. to 10 mfd. or more may be tested by this means. In some service stations a voltage as high as 200 volts is used to charge certain condensers to get a positive indication of the condenser's condition. However, satisfactory results may be expected in the usual line of servicing by taking power from the 110 volt lighting circuit with a series lamp in the circuit as shown in Figure 19. A standard 110 volt filament type lamp or a 110 volt neon lamp may be used in the test socket. No harm would be done even if a shorted condenser were connected to this circuit because the lamp would carry to full voltage of the line. If either type lamp glowed to its full brilliancy with a condenser in the line as shown it could be assumed that the condenser was shorted. Upon discharging a condenser of high capacity you should get a good snappy spark and often you will get a second spark discharge if you again short the terminals; the second spark, of course, will be much weaker than the initial discharge spark.

Figure 21 shows how a fixed condenser is placed in series with a capacity meter and the line supply to read the capacity of the condenser directly in microfarads. The range on the meter scale is selected according to the particular condenser under examination; no reading would indicate an "open" condenser and full-scale reading, or a certain point marked on the scale, would indicate a "shorted" condenser.

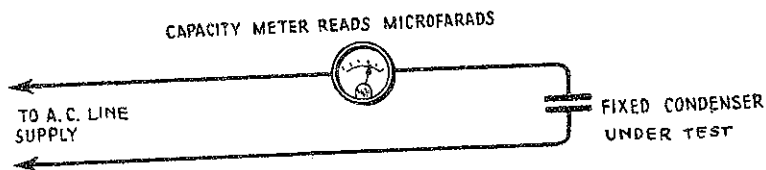


Figure 21

"Leaky" Condenser. If a condenser of fairly high capacity is leaky it can be easily discovered by charging it up in the usual manner and then waiting about five minutes before discharging it. If you discharge the condenser after this length of time and get a good healthy spark of the same intensity as you would get when discharging it immediately after charging it then you can be rest assured that the condenser is O.K. A condenser that will not hold its charge is called a "leaky" condenser, as the name implies, and the quicker it loses its charge the greater is the leakage. As a rule small capacity condensers do not hold their charge very long but they can be tested by charging them with a "B" battery and in a few moments discharging them through a telephone headset as previously explained.

Testing a Condenser Block or Condenser Bank. Each condenser in a condenser block must be tested separately if you suspect trouble. Before making an

actual test all leads except the common lead should be disconnected from the terminals to free the condensers from their respective circuits so that there cannot be any possibility of an electrical circuit across any condenser through other parts in the radio set. Each condenser is then tested in the usual way by charging it and discharging it, or by employing a capacity meter if one is available. Let us add at this time that you should never apply an alternating current to an electrolytic type condenser for test purposes as it may result in damaging or destroying the condition of the electrodes since they are polarized.

- (4) Our fourth explanation deals with continuity testing of a circuit and, hence, you will find the next part of your work to be a combination of Explanations 1, 2, and 3 which you have just studied. The continuity tests pictured in Figures 22 and 23 are practical examples of how various parts, such as coils, resistors, and condensers might be connected together and to the ground side of a receiver to form a certain section of a circuit. First let us mention that you should carefully go over all terminal and soldered connections, screws, nuts, and so on, to be sure that there is a good electrical connection at all points, and if necessary use a stick of wood, such as a dowel stick, for prying firmly but gently against all connections to open up and locate any poorly soldered joints, or loose connections, or wiring broken under its insulation.

A continuity test such as these drawings suggest may be used to check all of the circuits in a radio set and it will be found to be one of the quickest ways for locating trouble within the set after making a socket-analysis test. To perform a test you simply touch the two test leads to the respective ends of the circuit or section of the circuit under examination. Just where you would start in any case would depend upon the conditions present at the time of the test, or in other words, depending upon whether or not you have localized the trouble.

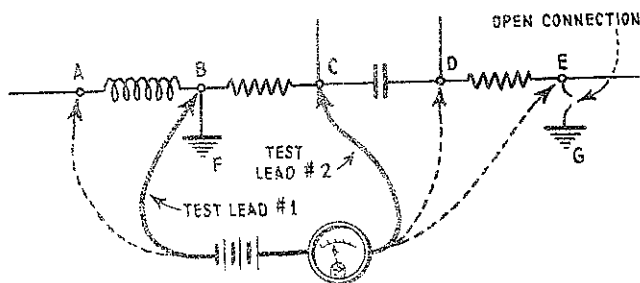


Figure 22

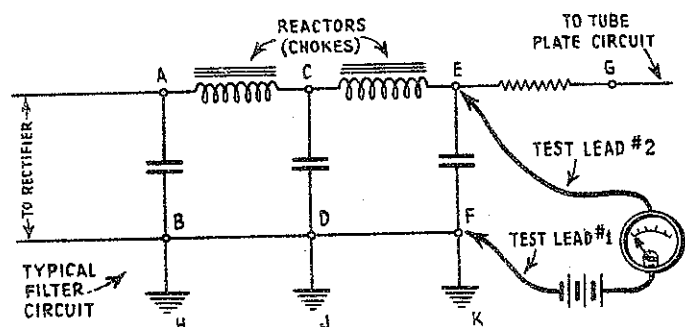


Figure 23

If the wiring in either of the above circuits is continuous, and all connections are in good condition the meter will give a full scale reading when you touch your test points along different portions of the wiring. A low reading would indicate a high resistance joint, and no reading an open connection or broken wire. When testing through a winding or a resistor of high resistance by touching the test leads to the terminals of the unit we should get a low reading and vice versa. Thus, by getting a reading which is either zero, maximum, or too high or too low you can in most cases determine whether a winding is open, shorted, or normal. To sum up these points we can say that when touching the test

leads across a metallic circuit we should get a reading on the meter and the actual reading will differ with the resistance of the circuit or part under test. In the case of condensers we should get no steady reading on the meter when touching the test leads across a condenser's terminals, except perhaps we might notice a small momentary deflection due to the charging current. You should be careful not to confuse a short-circuit indication when testing a by-pass condenser in its circuit which might be caused by the shunting effect of some metallic part such as a transformer winding, or choke coil, or some other unit in the circuit. That is why we suggested that at least one terminal wire should be disconnected from a condenser when the circuit diagram tells you that other parts are connected around the condenser in question.

The correct and incorrect indications for continuity testing of the circuits in Figures 22 and 23 are as follows:

Refer to Figure 22.

With test leads #1 and #2 touching points A and B you should get a reading. No reading indicates an open circuit. You should get the same indications with the test leads on the following points: A and C, B and C, D and E, F and G which are both grounds in the radio set. Also, you should get the same indication between points E and G, but you will not, in this instance, because we have purposely shown the wire connection broken. The meter will not read with test leads #1 and #2 on points E and G. With the test leads on points C and D we should get no reading, that is, no steady reading. A reading would indicate a shorted condenser.

Refer to Figure 23.

With test leads #1 and #2 touching points A and C you should get a reading. No reading would indicate an open circuit. You should get the same indication, that is, a closed circuit indication between all of the following points: C and E, E and G, G and C, B and D, D and F, A and G, A and E, and any other combinations where a metallic circuit is formed through which the direct current of the battery can flow. There should be no indication when testing across either of the three filter condensers. In testing from A to B, or C to D, or E to F, you should get no reading as just stated, but if you did in an actual radio set it could be taken to mean that either a condenser was shorted or some metallic circuit was shunted around the condenser. The thing to do in a case like this is to disconnect at least one terminal wire of each condenser and then make your continuity test or other condenser tests as outlined in the foregoing paragraphs. Of course, you should get a reading between H and J, J and K, or when testing between any two grounded parts of the set or the wiring which connects to the ground.

Testing Variable Type Condensers. It is an easy matter to test for a possible short between the plates of a variable condenser. To make this test you place one test point of your continuity tester on one terminal of the condenser and the second test point on the other terminal, and then rotate the movable plates slowly back and forth completely across the dial. If a rotor plate touches a stator plate at any point it will be evidenced by a reading on the test meter since the circuit would be closed at that point. The condenser should be disconnected from any coil or part that might furnish a shunt circuit around the condenser which would interfere with your test indication. There are sufficient helpful suggestions given in the foregoing explanations to enable most anyone to work intelligently when making a continuity test of a receiver's circuits, or when checking up on the individual parts.

COMMON SERVICE COMPLAINTS AND POSSIBLE CAUSES OF TROUBLE.

It would be advisable for a serviceman to familiarize himself with the more common service complaints and the various troubles that are in general accountable for these complaints. With this knowledge at hand it is often possible to go more directly to the seat of trouble that is causing a receiver to give unsatisfactory results. If imperfect operation of a receiver is not due to any of the causes we have given under the following headings the cause might be due to some condition peculiar to a certain set and in this event it would be best to consult the service notes for this set if they are available.

WEAK RECEPTION OR LOW VOLUME.

- Defective tubes or dirty prongs on tubes.
- Tubes operating with incorrect voltages.
- High resistance joints or poor contacts.
- Open by-pass condenser.
- Radio-frequency circuits out of balance.
- Open antenna circuit.
- Open ground circuit.
- Reversal antenna and ground connections.
- Low voltages from socket power unit.
- Defective socket power unit.
- Defective r-f transformer.
- Compensating condenser out of adjustment.
- Trimmer condenser out of adjustment.
- Defective main tuning condenser.
- Make sure grid clips on screen-grid tubes make good contact.
- Magnetic pick-up will help check this trouble. If pick-up operates perfectly the trouble is in the radio-frequency side, otherwise the trouble must be in the detector or audio-frequency circuits.

POOR TONE QUALITY OR DISTORTION.

- Defective tubes.
- One or more tubes working with incorrect voltages.
- Defective speaker or out of adjustment.
- Open by-pass condenser or defective otherwise.
- Poor connections especially in voice coil circuit.
- Ground on bias resistor would allow certain tube to overload.
- Incorrect pressure or dirty contact arm of volume control.
- Defective a-f transformer.
- Volume control advanced too far.

POOR SELECTIVITY OR BROAD TUNING OR NO RECEPTION ON HIGHER FREQUENCIES.

- Unmatched r-f coils.
- Radio-frequency circuits out of balance.

NO SIGNAL.

- Defective tubes.
- One or more tubes working with incorrect voltages or no voltage.
- Open antenna.
- Grounded antenna.
- Reversal of antenna and ground connections.
- Open r-f coil.
- No power on the set or no voltage supplied to one or more circuits.
- Tuning condenser plates may be touching and causing a short.
- Wiring may be open at some point.

Loudspeaker may be inoperative — open in cone or voice coil circuit.
High resistance connection or rosin joint in r-f circuit wiring.
Insulated plate of a compensating condenser may be grounded.
Defective operating switch.
Loose volume control arm.
Defective transformer.
In d-c electric sets the socket plug must be inserted correctly to provide positive voltage to the corresponding positive voltage side of the receiver's circuits.

FADING.

Defective tubes.
Poor connections.
Atmospheric conditions may account for this for which there is no remedy.
Signal sent out by the broadcasting station may change intensity.

NOISY RECEPTION.

Defective tubes — microphonic tube or caused by audio feed back.
One or more tubes working on incorrect voltages.
Outside interference — natural static or man-made static.
In electric sets the attachment plug may need reversing in socket.
Loudspeaker rattles — cone out of adjustment or cone defective.
Open grid circuit in any stage may cause howling.

OSCILLATION.

Neutralize r-f circuits in sets using this system.
Incorrect screen-grid voltage.
Voltage too high on certain tubes.
Coupling between r-f stages — lack of shielding.
Defective cathode by-pass condenser.
Radio-frequency choke coils; incorrect inductance.
Volume control resistance grounded.
Cathode side of a cathode bias resistor might be grounded, thus reducing bias to zero.

HUM.

Laminations loose on filter choke.
Defective tubes.
One or more tubes working on incorrect voltages.
Grounded filament.
Attachment plug (socket plug) — reverse socket plug.
Antenna and ground leads reversed.
Arrangement of wiring not good.
Line voltage low.
Defective center tapped resistance unit.
Short-circuit in filter choke.
Open in filter circuit condenser.
Defective phonograph pickup switch which is controlled by volume control.
Check filament circuit of output power tube and heater circuit of other tubes.
Make sure only proper grounds are on the heater and filament circuits; these are usually made at center tap resistor shunting filament circuit and midtap of heater winding of power transformer.
A 100,000 ohm resistor shunted across the secondary of the last a-f input transformer of the push-pull type may eliminate hum, or a fixed condenser of approximately .002 mfd. connected to either end of this winding and grounded may improve conditions.

PROBABLE CAUSES FOR VOLTAGE OR CURRENT BEING TOO HIGH OR TOO LOW. The items which a serviceman might look to for determining the cause of high or low voltages or currents in the principal circuits are classified under three headings, namely, (1) plate circuit voltage and current, (2) grid circuit, (3) filament or heater circuit.

(1) PLATE CIRCUIT VOLTAGE OR CURRENT HIGH OR LOW OR ZERO. Possible causes are:

- Defective tube or tubes.
- Dirty tube prongs or loose or dirty socket contact.
- Poor connections.
- Open, ground or short in wiring.
- Shorted by-pass condenser, detector plate circuit.
- Defective transformer primary.
- Filament or heater voltage low.
- "B" battery weak or connections reversed.
- "A" battery weak or connections reversed.
- "C" battery or bias resistor connections reversed.
- Grid bias voltage too high or too low.
- Incorrect connections at power supply.
- Defective filter condenser in power unit.
- Defective filter choke " " "
- Defective voltage divider resistor in power unit.
- Defective high voltage winding of power transformer.
- Line voltage too low or wrong voltage tap adjustment.
- Shorted plate resistor, resistance coupling.
- Shorted coupling condenser, resistance or impedance coupling.
- Defective volume control.
- Open grid circuit generally causes fluctuating voltage.

(2) GRID CIRCUIT VOLTAGE HIGH OR LOW OR ZERO. Possible causes are:

- "C" battery low.
- Bias resistor resistance too low.
- Bias resistor short-circuited.
- Cathode-grid short inside of tube.
- Open circuit or wiring grounded.
- Socket contact and prongs making poor contact.

(3) FILAMENT OR HEATER VOLTAGE HIGH OR LOW OR ZERO. Possible causes are:

- Defective tube, heater or filament burned out.
- Open, or complete short in wiring.
- Wiring partially broken under insulation; only a few strands carry current.
- Broken terminal connection.
- Line voltage low.
- Power unit; d-c output low.
- Line voltage high with incorrect line voltage tap adjustment.
- Defective "OFF-ON" switch.
- Dirty or loose socket connections.
- Defective socket otherwise.
- "A" battery discharged.
- "A" battery terminal connections corroded.
- Filament resistor or rheostat open or otherwise defective.
- Improper type tube inserted in socket.
- In series filament wiring open shunt resistor.
- In a-c set, one tube filament or heater burned out, thus decreasing load on circuit.

TOOLS AND INSTRUMENTS FOR THE SERVICE KIT.

Time is a very important factor in our service work and, therefore, the testing instruments and general equipment should conform to a standard that will enable a serviceman to perform his service work satisfactorily and in the shortest possible time. The weight of a service kit should be given due consideration if it is to be carried around any great distance in making service calls and where you must rely on trains and cars for transportation. Through careful selection the kit should contain only such equipment that will meet your immediate needs and, hence, it would be quite impossible to suggest a list of tools that would satisfy the requirements of every serviceman. However, in the list immediately below you will find practically all of the items that one might consider essential in present day servicing.

It is obvious, of course, that there is no limitation as regards either weight or assortment of test equipment when it is intended only for use in the shop, or if an automobile or motorcycle is used for transportation.

Our suggestion of a serviceable kit holding the absolute minimum of tools and instruments that a serviceman should carry with him on a service call is outlined in the following list.

One standard set tester or analyzer.	} {Note: These are often combined in one case, or instrument.
One standard tube tester.	
A combination continuity and ohmmeter tester.	

Several screw drivers of assorted sizes as follows:

- 1 long thin screw driver.
 - 1 short thin screw driver for use on set screws of knobs, dials, etc.
 - 1 balancing screw driver or wrench to fit the slot or head of the adjustment screw or nut on the trimmer or neutralizing condenser of the receiver to be serviced.
- For making adjustments of this kind in certain receivers you may need a tool made of insulating material, such as bakelite or other similar material. You should determine what type of tool will be needed before going out on a service call.

Several pairs of pliers as follows:

- 1 long nosed type.
- 1 short nosed type.
- 1 regular duty type with flat nose and side cutter.

An electric soldering iron rated at about 75 watts.

Solder.

Non-corrosive flux.

Large cloth to lay your tools on.

If possible carry three or four tubes of types most generally used.

Also, take along any literature you may have such as service notes, schematic diagram or wiring diagram, and data on voltage and current values to be expected in a socket-analysis test of the particular set to be serviced.

Other articles that are useful in service work are given in the list below which is continued on the following page.

File.

Small hand drill with assortment of drills.

Jack knife.

(cont'd from preceding page,)

Pipe stem cleaner. This article comes in handy for cleaning out dirt and dust between condenser plates.

Short stick of wood about 3" long; a wooden dowel pin pointed at one end will do. This stick is to be used for locating broken and loose joints or defective soldering by gently but firmly prying against the wiring connections.

Small reamer. This tool is needed occasionally when replacing parts for enlarging mounting holes which do not exactly line up.

Set of socket wrenches made especially for radio work.

One pair of telephone receivers (headset).

One sheet of fine sandpaper for cleaning prongs on tube bases.

Pocket flash light.

Small pocket mirror for inspection of wiring and parts in inaccessible places.

Spare coil of No.18 rubber-covered stranded wire.

Roll of insulating friction tape.

4.5 volt "C" battery. This battery is usually included in a set tester.

Vacuum tubes. It is suggested that a serviceman ascertain what kind of tubes are used in the set to be serviced and carry at least one good tube of each type for substitution. The following types represent the tubes in most common use today: 199, 201-A, 171-A, 222, 224, 226, 227, 245, and a 280. All tubes should have been previously tested both for normal operation and for microphonic tendencies.

Hydrometer. This instrument is needed whenever any amount of storage battery testing is to be done. A hydrometer should always be carried in a metallic container to prevent damage from acid or breakage.

Modulated oscillator and output meter. These instruments may or may not be needed according to broadcast conditions prevailing in your neighborhood. More accurate comparative tests on receivers can be conducted by visual means through the use of said instruments than by relying on the broadcast signals and aural reception through the use of headphones or loudspeaker.

Meters. If a set tester is not at hand you should be provided with at least two meters; one d-c voltmeter and one a-c voltmeter both with suitable ranges.

It is quite unnecessary to go into an explanation about the use of ordinary everyday tools, such as, screw drivers, pliers, and so forth and, therefore, we will merely offer our students a word of advice on the care that should be exercised in general when working on radios. Be careful in your soldering not to make rosin joints or break any wires which are used in making connections; do not damage or burr the edges on nuts or binding posts; do not damage insulation on wires when making tests; do not allow wires to become frayed or cut where they pass through holes or rest against sharp edges of parts or chassis, and be very careful in handling all radio parts and cabinets in general, and especially when removing a chassis from or reinstalling it in its cabinet.

NORMAL CHANGES IN PLATE CURRENT IN MILLIAMPERES
WHEN A GRID TEST IS MADE

Type of Tube	Plate Voltage							
	22.5-45	67.5	90	135	157-180	250	350	425
WD-11-12	1.50	1.58	1.90	-	-	-	-	-
'00-A	2.95	-	-	-	-	-	-	-
'01-A	1.90	2.50	3.20	3.35	-	-	-	-
'10	-	-	-	-	4.84	5.86	6.60	6.82
'12-A	-	-	6.60	7.40	7.48	-	-	-
'20	-	-	1.88	2.20	-	-	-	-
'22	-	1.14	1.18	1.23	-	-	-	-
'24	-	-	-	2.5	3.0	-	-	-
'26	-	-	3.83	3.83	3.83	-	-	-
'27	-	-	3.19	3.60	3.83	-	-	-
'30	-	-	5.0	-	-	-	-	-
'31	-	-	4.0	-	-	-	-	-
'32	-	-	-	-	-	-	-	-
'40	-	-	.88	.88	.88	-	-	-
'45	-	-	-	-	8.00	8.00	-	-
'50	-	-	-	-	-	7.35	9.34	10.58
'71-A	-	-	5.28	5.98	6.38	-	-	-
'99	1.40	1.67	1.83	-	-	-	-	-

Note: A 4.5 volt grid shift was used throughout to give the various readings on the above chart. If a 22.5 volt shift were used on any tube the change in plate current would be correspondingly greater.

RELATION OF PLATE VOLTS, GRID VOLTS, AND PLATE CURRENT
OF VARIOUS TUBES USED AS AMPLIFIERS

Type of Tube	Plate Volts	Grid Volts	Plate Current	Type of Tube	Plate Volts	Grid Volts	Plate Current
'01-A	67.5	3.0	1.7	'30	90	4.5	2.0
	90	4.5	2.5	'31	90	15.0	4.0
	135	9.0	3.0		135	22.5	8.0
	250	18.0	12.0	'32	135	3.0	1.5
'10	350	27.0	16.0	With 67.5 Volts on Screen Grid			
	425	35.0	20.0	'45	180	34.5	26.0
	135	9.0	7.0		250	51.5	32.0
	157	10.5	10.0	'50	300	54.0	35.0
'12-A	180	13.5	10.0		350	63.0	45.0
	90	16.5	3.2		400	70.5	55.0
	135	22.5	6.5		450	84.0	55.0
	135	1.5	1.5	'71-A	135	27.0	16.0
'20	With 45 Volts on Screen Grid				157	33.0	18.0
	180	1.5	4.0		180	40.5	20.0
	With 75 Volts on Screen Grid			'99	45	1.5	1.0
	90	6.0	3.5		67.5	3.0	1.7
'24	135	9.0	6.0		90	4.5	2.5
	180	13.5	7.5				
	90	6.0	3.0				
	135	9.0	5.0				
'26	180	13.5	6.0				
'27							

EXAMINATION - LESSON 40

1. (a) What is the purpose of a modulated oscillator? (b) Describe one type of modulated oscillator with which you are familiar.
2. How may the signal strength of a modulated oscillator be controlled?
3. Is there more than one place where an output meter may be connected to a receiver? Explain.
4. Show by a schematic diagram how a grid dip meter circuit is arranged and, also, explain its operation.
5. Are there any precautions to be observed in building or handling a socket-powered modulated oscillator? Explain.
6. (a) On what principle does a vacuum tube voltmeter function? (b) Why do you adjust the meter in this instrument to give a zero or nearly zero reading before taking measurements with it? (c) In general what are the practical considerations in regard to operation and setting up a vacuum tube voltmeter to make audio comparison tests?
7. Describe a method for checking up on a radio-frequency coil in a receiver to determine whether or not its turns are shorted. It is assumed that you cannot determine this fault by visual inspection because the turns in the coil under examination are so arranged that you cannot see all of the windings.
8. Describe three methods for testing small and large condensers used in radio receivers and their associated power and filter circuits. In neat form draw a small sketch of each method you describe and in some way identify each sketch so that we will know exactly what drawings you refer in your descriptions.
9. Let us suppose that you are using an output meter to check up on different receivers that you are called upon to service. (a) If you were neutralizing the r-f circuits of a certain receiver how would you know from the meter's indication when you had found the best adjustments? (b) If you were synchronizing the tuned r-f circuits of a single-dial receiver how would you know from the meter when you arrived at the best adjustments?
10. Can you use a continuity tester to check with absolute certainty the condition of a fixed condenser? Give reasons for your answer.